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Prevalence and Determinants of Left Ventricular Geometric and Functional Abnormalities in Asymptomatic Hypertensive Adults at a Tertiary Hospital, South-Southern Nigeria

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Abstract **BACKGROUND:** Hypertensive left ventricular hypertrophy (LVH) is a predictor of cardiovascular morbidity and mortality. Left ventricular geometric pattern further increases the cardiovascular disease burden among hypertensives. The aim of this study was to determine the prevalence, determinants, pattern of left ventricular geometry, and left ventricular (LV) functional status of hypertensives, pre-hypertensive, and normotensive Nigerians. **METHOD:** A cross-sectional comparative study conducted at the University of Port Harcourt Teaching Hospital, Rivers state, Nigeria. Clinical and trans-thoracic echocardiography was performed among recruited patients with normal blood pressure, pre-hypertension, and newly-diagnosed hypertension. Two socioeconomic indicators (education and occupation) were employed to estimate the effect of socioeconomic status (SES) on LV structure and geometry. **RESULTS:** A total of 218 subjects were studied, 121 newly-diagnosed hypertensives, 60 pre-hypertensives, and 37 normotensives. The mean age of the hypertensive patients was 51.32±13.1 years, the pre-hypertensives was 50.25±13.0 years, while the normotensives was 47.76±12.0 years. This study showed that individuals within the lower SES had higher blood pressure (BP) levels. Lower educational class was inversely associated with the presence of LVH and LV remodeling. This study also found that central obesity was more prevalent among the lower social classes than among the upper and middle class (p=0.020). Subjects with pre-hypertension had higher values of most echocardiographic parameters than those with normotension. The prevalence of concentric remodeling, eccentric hypertrophy and concentric hypertrophy were 28.8%, 5.85, and 34.6% in the pre-hypertension group, and 16.9%, 14.6%, and 65.2% in the hypertension group. Logistic regression analysis showed that only diastolic blood pressure (DBP) was an independent risk factor for concentric remodeling, concentric hypertrophy, and eccentric hypertrophy (OR=0.257, p=0.006). This study also showed that impaired LV diastolic dysfunction occurred earlier than systolic dysfunction with an associated greater atrial contribution to LV filling. **CONCLUSION:** In countries undergoing epidemiological transition, effects of socioeconomic status on blood pressure and other cardiovascular risk factor may require more than a casual assessment. Left ventricular geometrical changes exist in adults with pre-hypertension and hypertension in South-Southern Nigeria and may be influenced by social stratification. The geometric changes are strongest among the lower social classes and may be due to higher BP levels. There is a need to develop and test appropriate social interventions to correct social inequalities among the populations to reduce the impact of social factors on cardiovascular health.

Keywords Left ventricular hypertrophy, Geometric pattern, and functional abnormalities

1. Background

Hypertension is one of the primary risk factors for cardiovascular disease [1]. It is currently the commonest cardiovascular disease in black Africans [2, 3]. Structural changes occur in the heart and vasculature as a consequence of established hypertension [4]. In hypertensive patients, an adaptive myocardial response to increased cardiac afterload results in left ventricular hypertrophy (LVH) [5].

Hypertensive LVH is a powerful independent predictor for sudden cardiac death [6], ventricular arrhythmias [7], myocardial ischemia [8], coronary heart disease [9], heart failure [10], as well as ischemic stroke [11]. LVH is defined as an increase in the mass of the left ventricle, which can be

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secondary to an increase in wall thickness, an increase in cavity size, or both [12]. In addition to the absolute increase in left ventricular mass (LVM), the pattern of structural adaptation of the left ventricle is influenced by the type of hemodynamic load to which it is subjected to. Therefore, of even greater prognostic importance are the various types of geometric patterns that may arise as a consequence of the hypertension [13]. Classification of the left ventricular geometric pattern using the left ventricular mass index (LVMI) and the relative wall thickness (RWT) yields the following patterns: normal, concentric remodeling, concentric hypertrophy, and eccentric hypertrophy [14]. It has been found that concentric hypertrophy appears to carry the highest risk and eccentric hypertrophy an intermediate risk [15].

Systolic and diastolic function of the left ventricle can also be significantly influenced by the geometrical patterns which are also important in cardiovascular prognosis [16].

Although these subjects do not have symptoms as a prerequisite for recruitment, some geometrical and functional changes of the heart may be detected by echocardiography. Some investigators had reported that untreated hypertensive patients had higher prevalence of geometrical and functional changes in left heart [17, 18], but data regarding the association between overt hypertensive/ pre-hypertensive patients and geometrical and functional changes of left heart are rare, especially in adults in South-Southern Nigeria.

2. Methods

Study population

Study subjects were randomly recruited from newly diagnosed and treatment naïve hypertensive patients attending the general out-patients, and medical out-patients clinics of the University of Port-Harcourt Teaching Hospital from January 2016 to August 2016. Those who were currently taking lipid-lowering drugs, contraceptive pills, and diabetics were excluded from the study. All participants underwent a routine clinical examination, blood biochemical examination and trans-thoracic echocardiography. Finally, 218 subjects were recruited as cases. These were further stratified into two groups of 121 persons with newly diagnosed hypertensive patients, 60 pre-hypertensive patients, and 37 normotensive individuals. Hypertension was defined as diastolic blood pressure (DBP) of ≥90 mmHg, and/or systolic blood pressure (SBP) of ≥140 mmHg, pre-hypertension as SBP of 120–139 mmHg and (or) DBP of 80–89 mmHg [19] as defined by JNC7. Written informed consent was obtained from participants and the ethical committee of the hospital.

Demographic and clinical characteristics

Demographic and clinical characteristics such as age, gender, duration of hypertension and current anti-hypertension therapy were obtained by a structured questionnaire. Blood pressure was measured with a standard mercury sphygmomanometer according to standard protocol [20]. Height, weight, waist circumference, hip circumference were measured manually. Body mass index (BMI) was calculated as weight (kilograms) divided by height (meters) squared. Waist-to-hip ratio was also calculated.

Socioeconomic status variables:

Education and occupation were used as parameters for socioeconomic status (SES). Education was stratified into 4 groups: none, primary level, secondary level, or tertiary level. Occupation was stratified into six groups: upper class, middle class, junior management, skilled manual occupation, semi-skilled class, and the unskilled class.

Laboratory examination

Fasting venous blood were collected and analyzed in the chemical pathology laboratory of the University of Port Harcourt Teaching Hospital for lipid profile and blood glucose. Fasting cholesterol and triglyceride levels were measured using the enzymatic method. Fasting HDL-C was measured with the precipitation method. LDL-C values were calculated using the Friedewald equation when triglyceride level was less than 4.0mmol/L: LDL-C= TCH-(HDL-C+TG/2.2) [21].

A trans-thoracic echocardiographic study was done for all the patients with an Aloka Prosound SSD 4000 echocardiography machine equipped with a 2.5MHz transducer. With the patient in the left lateral decubitus position, targeted echocardiographic estimations were taken. These included the standard 2-Dimensional Oriented Motion-mode measurements of interventricular septal thickness in diastole, left ventricular posterior wall thickness in diastole, and left ventricular end diastolic diameter just beyond the tips of the mitral valve leaflets. Left ventricular mass was calculated using the American society of Echocardiography formula modified by Devereux [22].

$$\text{LVM (gm)} = 0.8 \times [1.04\,(\text{LVIDd} + \text{PWTd} + \text{IVSd})^3 - \text{LVIDd}^3] + 0.6\text{g}$$

Where:
LVIDd = Left ventricle internal diameter in diastole
PWTd = Posterior wall thickness in diastole, and
IVSd = Interventricular septal thickness in diastole.

Left ventricular mass was indexed to body surface area using cut-off values of 134g/m^2 and 110g/m^2 for men and women respectively. [22]

Relative wall thickness (RWT= 2 × posterior wall thickness in end diastole/LV diastolic diameter in end diastole) was calculated. A partition value of 0.45 for RWT was used for both men and women [23]. Patients with increased LV mass index and increased RWT were considered to have concentric hypertrophy, and those with increased LV mass index and normal RWT were considered to have eccentric hypertrophy. Those with normal LV mass index and increased or normal RWT were considered to have concentric remodeling or normal geometry, respectively.

Statistical analysis

Data was expressed as mean± standard deviations and frequencies as a percentage. Continuous variables were compared with the Students t-test or one-way analysis of variance (ANOVA) as considered appropriate. Proportions or categorical variables were compared with the Chi-square test. Relations among continuous variables were assessed using Pearson correlation coefficient and linear regression analysis. Multiple logistic models were constructed to elucidate the independent determinants of LV remodeling. The odds ratio and 95% confidence intervals were calculated. All analyses were performed by SPSS statistical software (version 19.0, SPSS Inc). *P* values of <0.05 were considered statistically significant.

3. Results

Baseline clinical characteristics and biochemical parameters of total subjects are shown in Table 1. The age of the study participants ranged between 20 and 86 years with a mean age of the hypertensive patients being 51.32±13.1 years, the pre-hypertensive cohorts 50.25±13.0 years, and the normotensives 47.76±12.0 years (p=0.339). Majority [66.5%] of the participants were in the 40-59 years' age-group.

There were more females than males among the hypertensive cases in a ratio of 1.3:1 as 57.0% of them were females and 43.0% were males. Among the pre-hypertensive subjects also, females accounted for 56.7% giving a female to male ratio of 1.3:1. While among the normotensive cohorts, females accounted for 45.9% of the population giving a ratio of 0.8:1 (X^2=1.493, p=0.474).

The mean waist circumference of the hypertensive patients was 97.1±12.11cm while that of the pre-hypertensive group was 91.5±20.43cm and the normotensive subjects had a waist circumference of 86.1±12.06cm (p<0.001). The body mass indexes (BMI) of the different groups were as follows: 29.3±4.85Kg./m^2, 28.8±4.63Kg/m^2, and 26.4±5.98Kg/m^2 for the hypertensives, pre-hypertensive, and normotensive subjects respectively (p=0.006).

The mean systolic blood pressure (SBP) for the hypertensive patients was 151.6±2.03mmHg while the SBP for the pre-hypertensive subjects was 126.9±8.11mmHg, and that for the normotensive cohort was 108.7±18.5mmHg (p<0.001). The mean diastolic blood pressure (DBP) for the hypertensive patients was 94.5±13.27mmHg while the DBP for the pre-hypertensive subjects was 79.7±9.38mmHg, and that for the normotensive cohort was 64.9±8.98mmHg (p<0.001).

Socioeconomic variables and LVH

We found that the subjects with no formal education made up 7.31% of the population, while those with primary, secondary, and tertiary levels of education made up 13.24%, 25.11%, and 54.34% of the population respectively (Figure 1). Most of the study populations were in the junior management social class (37.16%), while the upper class made up 1.38% of the population (Figure 2). A larger proportion of the males were of the upper social class (66.7%) while the females made up 67.6% of the unskilled social class (X^2=23.163, p<0.001). The mean SBP of the skilled manual social class was the highest among the lower social classes (p=0.003) (Figure 5). We found that the subjects with elevated blood pressure, systolic and diastolic, were mostly of the skilled manual social class [SBP: (X^2=18.311, p=0.003)] and [DBP: (X^2=13.099, p=0.022)] respectively. We also found that all the subjects in the upper, and most in the middle classes had tertiary levels of education while those with no formal level of education were of the lower social classes (X^2 =123.694, P<0.001) (Table 5). Non-parametric correlation analysis showed significant correlation between social status and educational level (r=0.529, p<0.001). Further analysis with linear regression also revealed education level was predictive of social class (r=0.534, p<0.001). Eighty-three percent of the subjects with no formal level of education, 76.2% of those with primary level of education, 68.9% of those secondary level of education, and 49.5% of subjects with tertiary level of education had left ventricular hypertrophy (X^2=10.893, P=0.012). There was also a negative but significant association between educational level and LVH (r=-0.236, p=0.001). Linear regression analysis also revealed that educational level was predictive of LVH (r=0.242, p<0.001). Multiple logistic regressions was then performed using the presence of LVH as the dependent variable while educational status, waist circumference, SBP, and DBP were included in the model as independent variables. The presence of LVH was significantly and independently predicted by waist circumference (OR= 1.031, 95%CI; 1.001-1.061, p=0.040) and DBP (OR= 1.038, 95% CI; 1.001-1.077, p=0.046). Over 91.7% of the subjects with no formal education had some form of left ventricular remodeling, 100% of those with primary level of education had LV remodeling, 77.8% of those with secondary education, and 73.7% of those with tertiary level of education had some form of LV remodeling (X^2=8.454, P=0.038). We also found that those lower educational status had been hypertensive for longer duration of time than their more educated counterparts, although this was not statistically significant (X^2= 9.420, P=0.151). This study also found that central obesity was more prevalent among the lower social classes than among the upper and middle class (X^2 = 13.339, p=0.020).

Prevalence of LVH

In the whole study population, mean LV mass index to BSA ranged was 172.9±66.83g/m^2, 113.9±36.70g/m^2 and 108.6±53.77g/m^2 for the overtly hypertensive, pre-hypertensive, and normotensive subjects respectively (p<0.001) (See Figure 3).

Overall, 104 subjects (60.12%) were found to have LVH when LVMI was indexed to BSA. The prevalence of LVH consistently varied among the study groups with highest prevalence found amongst the hypertensive patients (80.9%), followed by the pre-hypertensive subjects (43.4%), and least so (29.0%) among the normotensives (p<0.001). Prevalence rates of LVH were lowest in the 40-59 years age group (51.6%) and highest in the over 80 year's age group (100%) (X^2=13.609, p=0.003). There were more males with LVH (61.3%) than the females (59.1%), the difference was however not statistically significant (X^2=0.080, p=0.777).

Prevalence of LV geometric patterns

The patterns of LV geometry in the entire study population were as follows: normal geometry (20.8%), concentric remodeling (20.8%), concentric hypertrophy (48.0%), and eccentric hypertrophy (10.4%).

In Table 3, it is shown that normal LV geometry was present in majority of the normotensive patients (53.1%) while eccentric and concentric hypertrophy were more in patients with hypertension (14.6% and 65.2%) and concentric remodeling was more in the pre-hypertensive group (28.8%) (Figure 4).

Demographic and echocardiographic characteristics of different LV geometric patterns

The difference between LV geometrical patterns across the groups was significant (X^2=48.970, p<0.001).

Normal geometry is more frequent in females than males (26.1% vs. 14.8%) while concentric remodeling and eccentric hypertrophy is more frequent in males than females (24.7% vs. 17.4% and 13.6% vs. 7.6% respectively). Concentric hypertrophy was more frequent in females than in males (48.9% vs. 46.8%).

Eccentric hypertrophy did not differ much between male and female (23.8% vs. 21.0%). The difference in presentation of LV geometrical patterns with sex was not statistically significant (p=0.155).

In Table 4, Normal geometry and concentric hypertrophy LV patterns were more prevalent in patients with mean age around 52 years while concentric remodeling and eccentric hypertrophy patterns were more prevalent in patients with mean age above 48 years (p=0.110).

Clinical and echocardiographic characteristics of different LV geometrical patterns

In Table 4, there was a progressive increase in mean systolic, and diastolic blood pressure in patients with normal geometry to patients with concentric hypertrophy, followed by decline in patients with eccentric hypertrophy (p<0.001). In Table 3, we present the classification of LV geometry patterns according to BP groups, and there was statistically significant difference across the groups (p<0.001).

Abnormal LV geometrical pattern presentation with waist circumference was present in patients who had central adiposity. Concentric hypertrophy was present in most patients (58.3%) who had increased waist circumference compared to patients with concentric remodeling (19.0%) and (6.0%) eccentric hypertrophy (p=0.04).

Functional correlates of different LV geometrical patterns

There was reduction of LV ejection fraction in 27.7% of the hypertensive patients, 25.8% of the pre-hypertensive subjects, and 25.2% of the apparently healthy (normotensive) cohorts (p=0.664). However, there was LV diastolic dysfunction as measured by E/A ratio in 56.8% of the hypertensives, 41.5% of the pre-hypertensives, and 22.6% of the normotensive subjects (p=0.003).

The left ventricular fractional shortening was normal for normal geometrical, concentric remodeling and concentric hypertrophy geometrical patterns and was lower for patients with eccentric hypertrophy (p=0.001). Likewise, the left ventricular ejection fraction was normal for normal geometrical, concentric remodeling and concentric hypertrophy geometrical patterns and was lower for patients with eccentric hypertrophy (p<0.001).

There was a significant difference regarding the interventricular septal wall thickness at end-diastole, left ventricular posterior wall thickness at end diastole, relative wall thickness, left ventricular mass indexed to body surface area across the different LV geometric patterns (Table 4).

Table 1. Clinical and biochemical parameters of the different study population

Variables	Hypertension	Prehypertension	Normotension	p-value
Age (years)	51.32±13.1	50.25±13.0	47.76±12.0	0.339
BMI (Kg/m^2)	29.34±4.85	28.77±4.63	26.38±5.49	0.006
WC (cm)	97.06±12.11	91.53±20.43	86.08±12.07	<0.001
WHR	0.93±0.09	0.90±0.08	0.91±0.22	0.455
SBP (mmHg)	151.60±22.32	126.87±8.11	108.70±18.50	<0.001
DBP (mmHg)	94.50±13.27	79.67±9.38	64.97±8.98	<0.001
TC (mmol/L)	4.99±1.13	5.13±1.00	4.44±0.81	0.005
TG (mmol/L)	1.16±0.45	1.11±0.48	0.87±0.44	0.004
HDL-C (mmol/L)	1.07±0.50	0.97±0.39	0.88±0.21	0.052
LDL-C (mmol/l)	3.43±0.99	3.60±0.91	3.17±0.77	0.095
FPG (mmol/L)	5.24±1.13	4.92±0.81	4.94±1.09	0.194

BMI=body mass index, WC=waist circumference, WHR=waist hip ratio, SBP=systolic blood pressure, DBP=diastolic blood pressure, TC=total cholesterol, TG=triglyceride, HDL-C=high density lipoprotein cholesterol, LDL-C=low density lipoprotein cholesterol, FPG=fasting plasma glucose.

Table 2. Echocardiographic parameters of different study population

Variables	Hypertension	Pre hypertension	Normotension	p-value
IVSD (cm)	1.39±0.36	1.09±0.26	1.02±0.37	<0.001
LVPWD (cm)	1.42±0.42	1.16±0.29	1.16±0.46	<0.001
LVIDS(cm)	4.79±0.84	4.57±0.82	4.37±0.78	0.034
LVIDD (cm)	6.33±2.59	2.91±0.69	3.08±0.68	0.586
RWT (cm)	0.60±0.15	0.52±0.17	0.49±0.22	0.001
LWMI (g/m^2)	172.89±66.83	113.85±36.69	108.61±53.77	<0.001
EF (%)	60.40±15.92	63.71±12.37	64.35±11.27	0.273
FS (%)	33.19±11.26	35.63±9.07	35.10±9.50	0.380
E/A	1.27±0.90	1.28±0.49	1.47±0.43	0.398
DT (ms)	190.03±57.91	173.83±53.57	179.65±48.65	0.227

IVSD=interventricular septal diameter in diastole, LVPWD=left ventricular posterior wall diameter, LVIDD=left ventricular internal diameter in diastole, LVIDS=left ventricular internal diameter in systole, RWT=relative wall thickness, LVMI=left ventricular mass index, EF=ejection fraction, FS=fractional shortening, E/A=E/A ratio, DT=deceleration time.

Table 3. Left ventricular geometric patterns according to blood pressure groups

Variables	NG (%)	CR (%)	CH (%)	EH (%)	Chi-square	p-value
Hypertension	3.4	16.9	65.2	14.5	48.970	<0.001
Prehypertension	30.8	28.8	34.6	5.8		
Normotension	53.0	18.8	21.9	6.3		

NG=normal geometry, CR=concentric remodeling, CH=concentric hypertrophy, EH=eccentric hypertrophy.

Table 4. Clinical and echocardiographic characteristics of different LV geometrical patterns

Variables mean±SD	Left ventricular geometrical patterns				
	NG	CR	CH	EH	p-value
Age (years)	51.19±10.65	47.36±10.26	52.64±13.42	48.06±7.65	0.110
BMI (Kg/m^2)	28.17±5.24	28.60±4.37	29.83±4.95	30.18±5.60	0.254
WC (cm)	90.91±14.60	93.57±12.86	98.34±12.43	96.94±12.31	0.028
WHR	0.88±0.08	0.95±0.22	0.93±0.07	0.93±0.12	0.124
SBP (mmHg)	118.33±18.28	130.14±18.77	144.13±23.93	139.44±22.87	<0.001
DBP (mmHg)	70.56±11.45	81.81±13.95	89.76±15.60	89.44±14.74	<0.001
LVIDD (cm)	2.96±0.67	2.69±0.55	7.18±0.05	4.57±1.03	0.665
LVIDS (cm)	4.70±0.50	4.03±0.65	4.61±0.71	5.93±0.78	<0.001
IVSD (cm)	0.85±0.17	1.10±0.23	1.46±0.33	1.22±0.28	<0.001
LVPWD (cm)	0.92±0.31	1.19±0.17	1.53±0.40	1.11±0.23	<0.001
LVMI (g/m^2)	83.16±19.12	98.68±22.65	177.35±54.97	193.18±74.09	<0.001
RWT	0.37±0.05	0.59±0.13	0.66±0.16	0.40±0.04	<0.001
EF (%)	65.03±11.43	64.23±9.65	63.20±14.53	47.33±17.84	<0.001
FS (%)	36.35±8.94	35.07±7.28	35.18±11.13	24.64±10.56	0.001
EV (m/s)	70.41±12.86	72.38±15.24	74.28±27.50	87.56±34.90	0.088
AV (m/s)	55.60±14.85	58.77±16.29	69.13±26.67	70.60±39.13	0.015
E/A	1.34±0.41	1.36±0.54	1.28±0.90	1.31±0.68	0.957
DT (ms)	176.00±42.93	184.53±53.62	182.95±51.61	194.39±89.61	0.721

Legend: NG = Normal geometry; CR = Concentric Remodeling; CH = Concentric hypertrophy; EH = Eccentric hypertrophy.

Table 5. Social Class with respect to Educational status

Variables	Upper Class (%)	Middle Class (%)	Junior Mgt (%)	Skilled (%)	Semiskilled (%)	Unskilled (%)	Chi-square	p-value	
No education	0(0)	0(0)	0(0)	9(56.3)	2(12.5)	5(31.3)	123.694	<0.001	<0.001
Primary	0(0)	0(0)	4(13.8)	6(20.7)	9(31.0)	10(34.5)			
Secondary	0(0)	1(1.8)	15(27.3)	19(34.5)	13(23.6)	7(12.7)			
Tertiary	3(2.5)	35(29.7)	62(52.5)	6(5.1)	12(10.2)	0(0)			

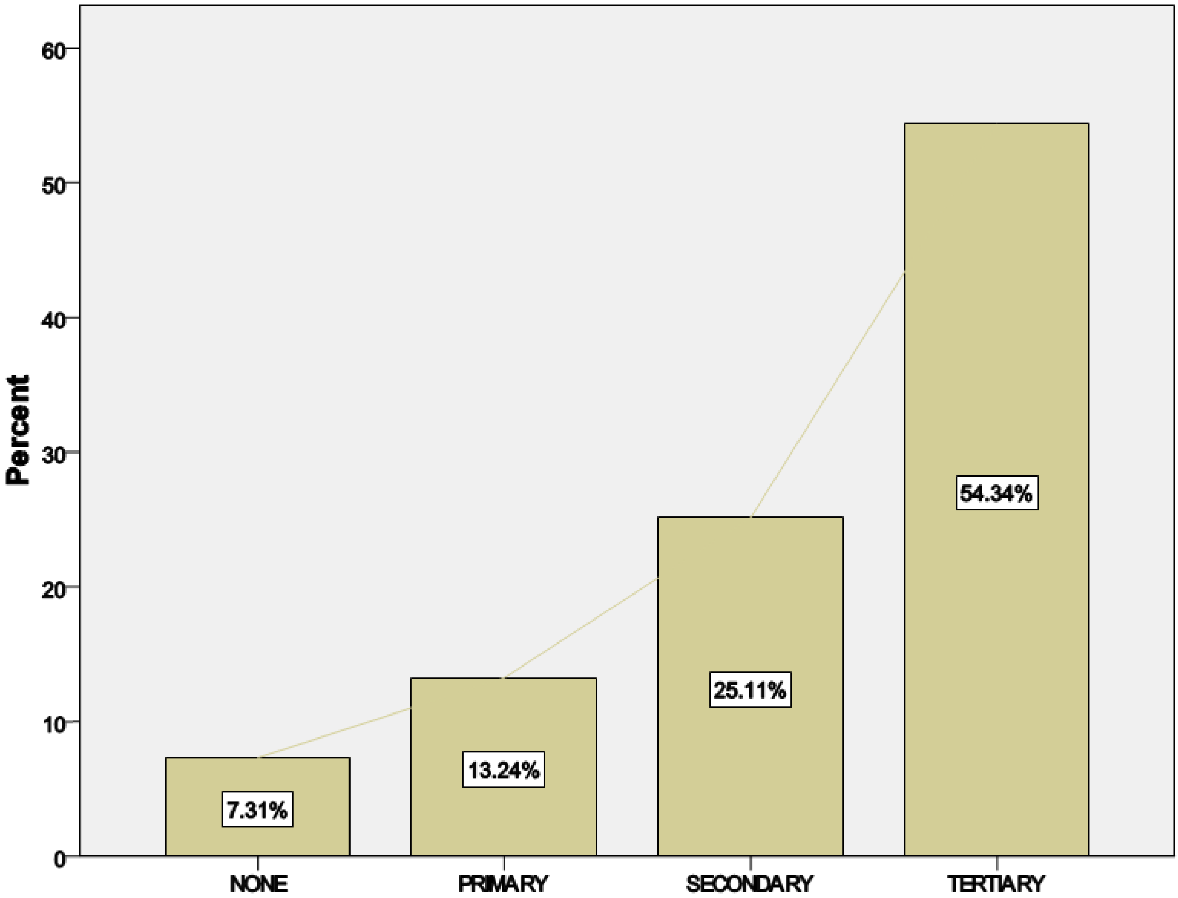

Figure 1. Distribution of educational status across the population

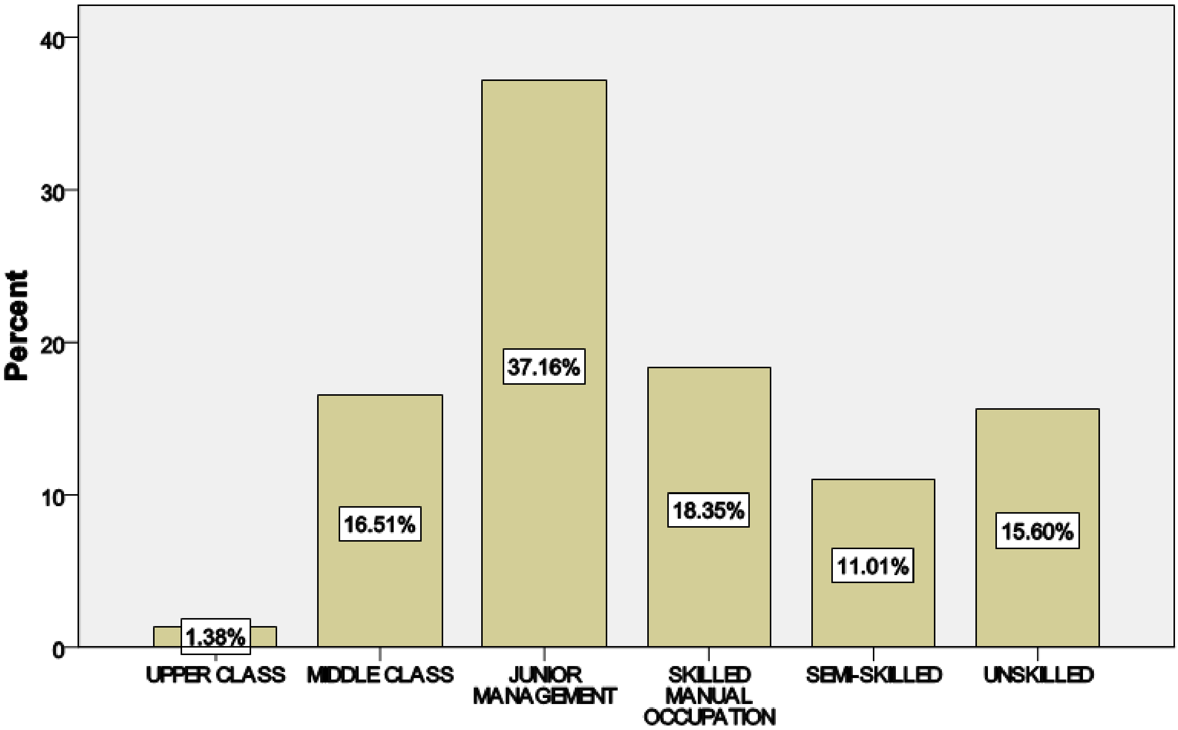

Figure 2. Distribution of the study population according to social class

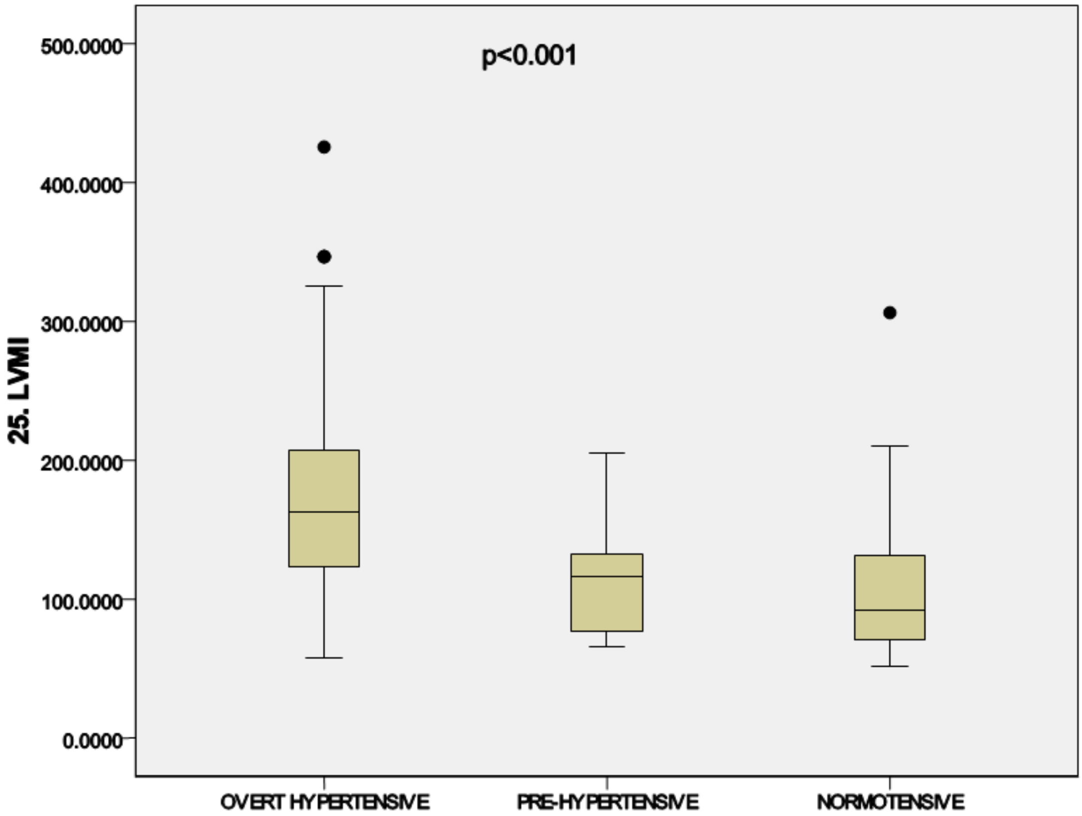

Figure 3. Diagram showing the mean LVMI across the groups

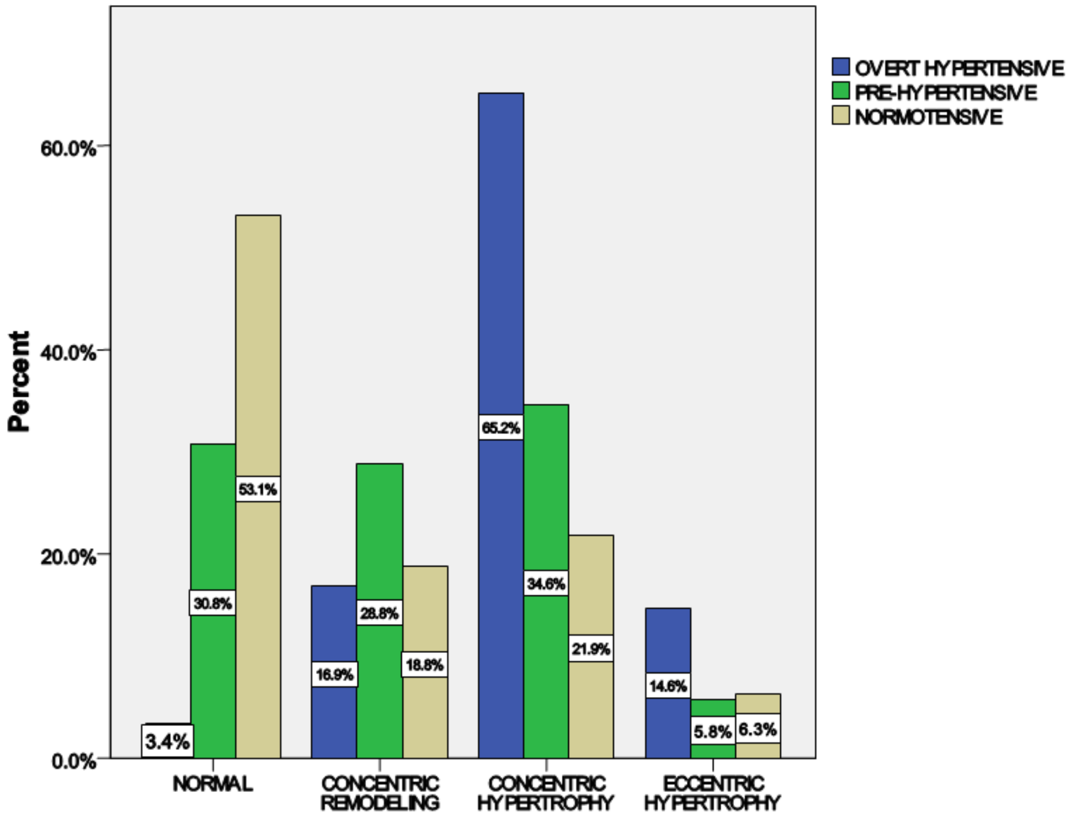

Figure 4. Distribution of LV geometric patterns across the groups

The left ventricular internal diameters during diastole was relatively higher in patients with normal geometrical than with concentric remodeling patterns but increased from patients with concentric remodeling to eccentric hypertrophy patterns. This difference was statistically significant ($p<0.001$). There was a progressive increase in the A wave (active late diastolic LV filling) velocity across the different LV geometric patterns ($p=0.015$).

Left heart remodeling in the study population and its association between BP indices, waist circumference and age.

Table 6 showed that DBP ($r=0.422$, $p<0.001$), SBP ($r=0.395$, $p<0.001$), and waist circumference ($r=0.210$, $p=0.006$) correlated significantly with left ventricular remodeling, while age did not correlate with left ventricular remodeling ($r=0.007$, $p=0.927$). However, after entering age, waist circumference, SBP and DBP into the multiple linear regression model, only DBP interacted as an independent predictor of left ventricular remodeling ($\beta=-0.323$, $p=0.006$). When logistic regression models was performed only DBP was an independent risk factor for left ventricular remodeling (OR=0.257, P=0.006).

4. Discussion

LVH was detected in 80.9% of subjects with hypertension but down to 43.4% of pre-hypertensives, and lowest among the normotensive subjects 29%. This finding is similar to what was reported by Stabouli *et al.* who reported a higher prevalence of LVH among pre-hypertensive and hypertensive children than normotensives [24]. The higher values reported in this study when compared to that reported by Saidu *et al* [25] despite a similar trend may be due to differences in intrinsic population characteristics of a given geographical location.

In this study, abnormal LV geometry was found in 79.2% of the entire study population. This was figure was slightly higher than 70% reported by Silangei *et al* [26] among treated and untreated hypertensives, 72% reported by Aje *et al* [27] and 75% reported by Isa *et al* [28] in newly diagnosed hypertensives.

The patterns of LV geometry in the entire study population were as follows: normal geometry (20.8%), concentric remodeling (20.8%), concentric hypertrophy (48.0%), and eccentric hypertrophy (10.4%).

LV remodeling was found in all the groups with concentric and eccentric hypertrophy predominating in the hypertensive group (65.2% vs. 14.8%), while concentric hypertrophy was more prevalent in the pre-hypertensive group (34.6%). Majority of the hypertensives in our study had concentric LV hypertrophy which was similar to the findings by other African investigators [26-28]. Other studies especially among Caucasians and Asians hypertensives reported eccentric hypertrophy as the prevalent LV geometric pattern [29, 30].

Although traditional cardiovascular risk factors form the basis of most cardiovascular risk predictions, these factors have been reported to explain only a fraction of the overall risk for cardiovascular disease (CVD) [31]. Across the globe socio-economic inequalities have been implicated as a cause of CVD [32]. A gradient of incidence of CVD mortality and morbidity and mortality has been reported across the spectrum of SES. This is mainly defined by income, occupation and educational status [33]. W e found that most (37.16%) of our study populations were in the lower social class (Figure 2). This study also revealed that most of the individuals with a higher level of education were of the higher socioeconomic class. This is important because it is a fact that socioeconomically disadvantaged groups are well associated with coronary heart disease and CVD mortality [34]. It has been reported that SES is closely related with quality of diet [35]. Low socioeconomic groups are known to prefer white bread, potatoes and rice [36] compared to those of high SES, who prefer wheat or wholegrain products that have low glycemic index as well as a greater amount of fibre [37]. The food types eaten by the low socioeconomic groups because of their high glycemic index lead to the accumulation of advanced glycosylated end-products (AGES) which have implicated in LVH [38]. This might partly explain why the subjects in the lower socioeconomic class in this study had a higher prevalence of LVH.

In addition, we found that the socioeconomic class also had an influence on LV geometry, with 91.7% of those with no formal education have some form of LV remodeling. This might be explained by the fact that people with higher SES tend to follow a rather more modern dietary pattern, while those belonging to the lower SES tend to adopt the more traditional dietary pattern [39]. Hiza *et.al* using the Health Eating Index-2005 as a means of measuring dietary quality demonstrated that adults with a tertiary level of education had higher scores for the consumption of whole fruit, total vegetables, whole grains, and calories from solid fats, alcoholic beverages compared to all education levels. Those with less than secondary school education had a lower score for oils and higher scores for saturated fat and sodium compared with all other education levels [40]. These individuals in the lower socioeconomic class are therefore more prone to the risk factors for LVH such as hypertension and central obesity. It is therefore not surprising that the individuals in this study in the lower socioeconomic groups had a higher prevalence of central obesity and mean SBP than those in a higher socioeconomic group. This finding was collaborated by Cois and Erlich in South Africa who reported an inverse relationship between educational status and blood pressure in females [41]. Multiple logistic regression analysis however reveals that the pathway through which SES impacts on the myocardium might be true obesity and hypertension.

Concentric remodeling was the most prevalent LV geometric pattern in the pre-hypertensive population. This was in contrast to the findings by Saidu *et al* [25] and Li *et al* [29] who both reported concentric remodeling as the predominant LV geometric pattern among pre-hypertensives.

The type of LV geometric pattern is determined to a great extent by the prevailing type of stressor on the myocardium, volume or pressure overload [42, 43]. Previous publications had highlighted the impact of hypertension on the LVM and geometric pattern [44, 45] but the effect of pre-hypertension on the myocardium has been largely unevaluated. Pre-hypertension has however been associated with accelerated development of LVH and diastolic dysfunction [46]. Also in the Framingham Heart Study, pre-hypertension was associated with increased incidence of myocardial infarction, stroke, hospitalization for heart failure and cardiovascular death [47]. Concentric remodeling and concentric hypertrophy may predominate in the early stages of the disease process due to the predominating pressure overload whereas eccentric hypertrophy progressively takes over with increased left ventricular mass due to increased volume overload [48]. It has been found that concentric hypertrophy appears to carry the highest risk followed by eccentric hypertrophy, concentric remodeling and normal geometry [49].

In our study, we observed that though there were variation in LV geometric pattern with respect to gender, this was not statistically significant. This was similar to the finding by Maisha *et al* [50]. This was however in contrast to the observation of Krumholz *et al* who reported gender-related differences in LV geometric pattern [51]. They however excluded from their study population subjects with diastolic hypertension which might explain the variation in observations.

There was a progressive increase in the mean SBP and DBP in patients with normal geometry to patients with concentric remodeling, concentric hypertrophy, followed by a decline in patients with eccentric hypertrophy. A similar observation was made by Silangei *et al* [26]. The reason for this is not far-fetched as pressure overload tend to predominate at the stages of concentric remodeling and concentric hypertrophy. With time however, the hypertrophied myocardium outstrips is coronary reserve leading to relative hypoxaemia, and apoptotic changes occurring in the myocardium. To overcome the wall stress occasioned by volume overload the chambers dilate with resultant decrease in SBP, DBP, and ultimately eccentric hypertrophy [26].

The most common pattern of LV geometry in our group of obese subjects was concentric LV hypertrophy. This was similar to the observation by Avelar *et al* [52] but in contrast to other investigators who reported eccentric hypertrophy as the predominant LV geometric pattern amongst obese subjects [52, 53]. The predominance of concentric LV hypertrophy suggests that sympathetic activation, elevated blood pressure could have contributed to the hypertrophy.

This study showed that impaired LV diastolic dysfunction occurred earlier than systolic dysfunction with an associated greater atrial contribution to LV filling. We also found that the hypertensive and pre-hypertensive groups had lower E wave and E/A, but higher A wave than the normotensive group. Hence, subjects with pre-hypertension already had LV diastolic abnormalities despite apparently normal systolic function. A similar finding was reported by other investigators [46, 54] who also reported diastolic dysfunction among patients in the early stages of hypertensive heart disease.

We also reported that DBP, SBP, and waist circumference correlated with LV remodeling. Result from multivariate logistic regression showed that only DBP was predictive of LV remodeling. This finding emphasizes the need to treat our hypertensive patients to goal and be more proactive in optimizing the blood pressure of our pre-hypertensive subjects.

5. Conclusions

The findings of this study strengthen the case that socioeconomic status in addition to traditional cardiovascular risk factors has a role to play in the prevalence of LVH. This effect might revolve around its association with hypertension and central obesity. The study also showed that type of LV geometric pattern was dependent on the BP phenotype. In this study we also reported that concentric remodeling was the most prevalent geometric pattern among the pre-hypertension group. Furthermore, we found that LV diastolic dysfunction was already present in this asymptomatic hypertensive and pre-hypertensive population. Finally, despite the fact that the population is undergoing some epidemiological transition, socioeconomic inequalities still persist and its effect on blood pressure and on the myocardium mostly overlooked should be of concern to the clinician.

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